



CLAIMS LISTING

1. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic communications network, comprising:

organizing a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,

comprising:

an antennae array of M antennae, where $M \geq$ one,

a transceiver for each antenna in said spatially diverse

antennae array,

means for digital signal processing to convert analog radio

signals into digital signals and digital signals into analog

radio signals,

means for coding and decoding data, symbols, and control

information into and from digital signals,

diversity capability means for transmission and reception of

said analog radio signals,

and,

means for input and output from and to a non-radio

interface for digital signals;

linking said set of nodes ~~being deployed~~ according to design rules that

favor ~~prefer meeting~~ the following criteria:

subdividing said set of nodes ~~further comprising into~~ two or more

proper subsets of nodes, with a first proper subset being ~~the~~ a

transmit uplink / receive downlink subset, and a second proper

subset being ~~the~~ a transmit downlink / receive uplink subset;

allowing each node in said set of nodes to simultaneously belong

~~belonging to no more~~ up to as many transmitting uplink or

receiving uplink subsets ~~than~~ as it has diversity capability means;

31 allowing each node in a the transmit uplink / receive downlink
32 subset has no more to simultaneously link to up to as many nodes
33 with which it will hold time and frequency coincident
34 communications in its field of view, ~~than~~ as it has diversity
35 capability means;

36 allowing each node in a the transmit downlink / receive uplink
37 subset has no more to simultaneously link to up to as many nodes
38 with which it will hold time and frequency coincident
39 communications in its field of view, ~~than~~ as it has diversity
40 capability means;

41 allowing each member of a the transmit uplink / receive downlink
42 subset cannot hold to engage in simultaneous, time and frequency
43 coincident communications with any other member of that transmit
44 uplink / receive downlink subset only if both that other member
45 also belongs to a different proper subset and the communication is
46 between different proper subsets;

47 and,

48 allowing each member of a the transmit downlink / receive uplink
49 subset cannot hold to engage in simultaneous, time and frequency
50 coincident communications with any other member of that transmit
51 downlink / receive uplink subset if both that other member also
52 belongs to a different proper subset and the communication is
53 between different proper subsets;

54 transmitting, in said wireless electromagnetic communications network,
55 independent information from each node belonging to a first proper subset, to one
56 or more receiving nodes belonging to a second proper subset that are viewable
57 from the transmitting node;

58 processing independently, in said wireless electromagnetic communications
59 network, at each receiving node belonging to said second proper subset,
60 information transmitted from one or more nodes belonging to said first proper
61 subset;

and,
dynamically adapting the diversity capability means and said proper subsets to
optimize said network.

2. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic
communications network, comprising:

organizing a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,

comprising:

a spatially diverse antennae array of M antennae, where M
 \geq two,

a transceiver for each antenna in said spatially diverse
antennae array,

means for digital signal processing to convert analog radio
signals into digital signals and digital signals into analog
radio signals,

means for coding and decoding data, symbols, and control
information into and from digital signals,

diversity capability means for transmission and reception of
said analog radio signals,

and,

means for input and output from and to a non-radio
interface for digital signals;

linking said set of nodes ~~being deployed~~ according to design rules that
favor ~~prefer meeting~~ the following criteria:

subdividing said set of nodes ~~further comprising~~ into two or more
proper subsets of nodes, with a first proper subset being a ~~the~~
transmit uplink / receive downlink subset, and a second proper
subset being a ~~the~~ transmit downlink / receive uplink subset;

93 allowing each node in said set of nodes to simultaneously belong
94 belonging to no more up to as many transmitting uplink or
95 receiving uplink subsets than as it has diversity capability means;
96 allowing each node in a the transmit uplink / receive downlink
97 subset has no more to simultaneously link to up to as many nodes
98 with which it will hold time and frequency coincident
99 communications in its field of view, than as it has diversity
100 capability means;

101 allowing each node in a the transmit downlink / receive uplink
102 subset has no more to simultaneously link to up to as many nodes
103 with which it will hold time and frequency coincident
104 communications in its field of view, than as it has diversity
105 capability means;

106 allowing each member of a the transmit uplink / receive downlink
107 subset cannot hold to engage in simultaneous time and frequency
108 coincident communications with any other member of that transmit
109 uplink / receive downlink subset only if both that other member
110 also belongs to a different proper subset and the communication is
111 between different proper subsets;

112 and,

113 allowing each member of a the transmit downlink / receive uplink
114 subset cannot hold to engage in simultaneous time and frequency
115 coincident communications with any other member of that transmit
116 downlink / receive uplink subset only if both that other member
117 also belongs to a different proper subset and the communication is
118 between different proper subsets;

119 transmitting, in said wireless electromagnetic communications network,
120 independent information from each node belonging to a first proper subset, to one
121 or more receiving nodes belonging to a second proper subset that are viewable
122 from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;
and,
dynamically adapting the diversity capability means and said proper subsets to optimize said network.

3. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:
using substantive null steering to minimize SINR between nodes transmitting and receiving information.

4. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:
using max-SINR null- and beam-steering to minimize intra-network interference.

5. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:
using MMSE null- and beam-steering to minimize intra-network interference.

6. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

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155 designing the network such that reciprocal symmetry exists for each pairing of
156 uplink receive and downlink receive proper subsets.

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158 7. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
159 adapting the diversity capability means and said proper subsets to optimize said network
160 further comprises:

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162 designing the network such that substantial reciprocal symmetry exists for each
163 pairing of uplink receive and downlink receive proper subsets.

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165 8. (original) A method as in claim 1, wherein the network uses TDD communication
166 protocols.

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168 9. (original) A method as in claim 1, wherein the network uses FDD communication
169 protocols.

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171 10. (original) A method as in claim 3, wherein the network uses simplex communication
172 protocols.

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174 11. (original) A method as in claim 1, wherein the network uses random access packets,
175 and receive and transmit operations are all carried out on the same frequency channels for
176 each link.

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178 12. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
179 adapting the diversity capability means and said proper subsets to optimize said network
180 further comprises

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182 if the received interference is spatially white in both link directions, setting

183 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,

184 where

185 $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used in the
186 downlink;

187

188 but if the received interference is not spatially white in both link directions,

189 constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to preferentially satisfy:

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191
$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

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193
$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2$$

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196 13. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein:

197 a proper subset may incorporate one or more nodes that are in a receive-only
198 mode for every diversity capability means.

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201 14. (original) A method as in claim 1, wherein:

202 the network may dynamically reassign a node from one proper subset to another.

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205 15. (original) A method as in claim 1, wherein:

206 the network may dynamically reassign a proper subset of nodes from one proper
207 subset to another.

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210 16. (PREVIOUSLY PRESENTED) A method as in claim 7, wherein the step of
 211 designing the network such that substantial reciprocal symmetry exists for the uplink and
 212 downlink channels further comprises:

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214 if the received interference is spatially white in both link directions, setting

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216 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link, where

217 $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used in the
 218 downlink;

219

220 but if the received interference is not spatially white in both link directions,

221 constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to preferentially satisfy:

222

$$223 \quad \sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$224 \quad \sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2$$

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227 17. (CANCELLED)

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231 18. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
232 adapting the diversity capability means and said proper subsets to optimize said network
233 further comprises

234 using at each node the receive combiner weights as transmit distribution weights
235 during subsequent transmission operations, so that the network is preferentially
236 designed and constrained such that each link is substantially reciprocal, such that
237 the ad hoc network capacity measure can be made equal in both link directions by
238 setting at both ends of the link:
239

$$240 \quad \mathbf{g}_2(k,q) \propto \mathbf{w}_2^*(k,q) \text{ and } \mathbf{g}_1(k,q) \propto \mathbf{w}_1^*(k,q) ,$$

241
242 where $\{\mathbf{g}_2(k,q), \mathbf{w}_1(k,q)\}$ are the linear transmit and receive
243 weights to transmit data $d_2(k,q)$ from node $n_2(q)$ to node $n_1(q)$
244 over channel k in the downlink, and where $\{\mathbf{g}_1(k,q), \mathbf{w}_2(k,q)\}$ are
245 the linear transmit and receive weights used to transmit data $d_1(k,q)$
246 from node $n_1(q)$ back to node $n_2(q)$ over equivalent channel k in the
247 uplink.
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251 19. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of each
252 ~~node in a transmit downlink / receive uplink subset having no more nodes with which it~~
253 ~~will hold time and frequency coincident communications in its field of view, than it has~~
254 ~~diversity capability means~~ linking said set of nodes according to design rules further
255 comprises:

256 designing the topological, physical layout of nodes to support the favored criteria
257 ~~enforce this constraint~~ within the node's diversity capability ~~means~~ means'
258 limitations.

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261 20. (CURRENTLY AMENDED) A method as in claim 1, wherein the step of each
262 ~~node in a transmit uplink / receive downlink subset having no more nodes with which it~~
263 ~~will hold time and frequency coincident communications in its field of view, than it has~~
264 ~~diversity capability means~~ linking said set of nodes according to design rules further
265 comprises:

266 designing the topological, physical layout of nodes to support the favored criteria
267 ~~enforce this constraint~~ within the node's diversity capability ~~means~~ means'
268 limitations.

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271 21. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
272 dynamically adapting the diversity capability means and said proper subsets to optimize
273 said network further comprises:

274 allowing a proper subset to send redundant data transmissions over multiple
275 frequency channels to another proper subset.

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278 22. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
279 dynamically adapting the diversity capability means and said proper subsets to optimize
280 said network further comprises:

281 allowing a proper subset to send redundant data transmissions over multiple
282 simultaneous or differential time slots to another proper subset.

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285 23. (CURRENTLY AMENDED) A method as in claim 1, wherein ~~said transmitting~~
286 ~~proper subset and receiving proper subset~~ the step of linking and substep of subdividing
287 said set of nodes into two or more proper subsets of nodes, does so using as the diversity
288 capability means for transmission and reception of said analog radio signals spatial
289 diversity of antennae. ~~further comprise:~~

290 ~~spatial diversity of antennae.~~

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293 24. (CURRENTLY AMENDED) A method as in claim 1, wherein ~~said transmitting-~~
294 ~~proper subset and receiving proper subset~~ the step of linking and substep of subdividing
295 said set of nodes into two or more proper subsets of nodes, does so using as the diversity
296 capability means for transmission and reception of said analog radio signals polarization
297 diversity of antennae further comprise:

298 ~~polarization diversity of antennae.~~

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301 25. (CURRENTLY AMENDED) A method as in claim 1, wherein ~~said transmitting-~~
302 ~~proper subset and receiving proper subset~~ the step of linking and substep of subdividing
303 said set of nodes into two or more proper subsets of nodes, does so using as the diversity
304 capability means for transmission and reception of said analog radio signals any
305 combination of temporal, spatial, and polarization diversity of antennae further comprise:

306 ~~any combination of temporal, spatial, and polarization diversity of antennae.~~

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309 26. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
310 dynamically adapting the diversity capability means and said proper subsets to optimize
311 said network further comprises:

312 incorporating network control and feedback aspects as part of the signal encoding
313 process.

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316 27. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
317 dynamically adapting the diversity capability means and said proper subsets to optimize
318 said network further comprises:

319 incorporating network control and feedback aspects as part of the signal encoding
320 process and including said as network information in one direction of the

321 signalling and optimization process, using the perceived environmental
322 condition's effect upon the signals in the other direction of the signalling and
323 optimization process.

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326 28. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
327 dynamically adapting the diversity capability means and said proper subsets to optimize
328 said network further comprises:
329 adjusting the diversity capability means use between any proper sets of nodes by
330 rerouting any active link based on perceived unacceptable SINR experienced on
331 that active link and the existence of an alternative available link using said
332 adjusted diversity capability means.

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335 29. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
336 dynamically adapting the diversity capability means and said proper subsets to optimize
337 said network further comprises:
338 switching a particular node from one proper subset to another due to changes in
339 the external environment affecting links between that node and other nodes in the
340 network.

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343 30. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
344 dynamically adapting the diversity capability means and said proper subsets to optimize
345 said network further comprises:
346 dynamically reshuffling proper subsets to more closely attain network objectives
347 by taking advantage of diversity capability means availability.

31. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

dynamically reshuffling proper subsets to more closely attain network objectives by accounting for node changes.

32. (PREVIOUSLY PRESENTED) A method as in claim 31, wherein said node changes include any of:

adding diversity capability means to a node, adding a new node within the field of view of another node, removing a node from the network (temporarily or permanently), or losing diversity capability at a node.

33. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

suppressing unintended recipients or transmitters by the imposition of signal masking.

34. (original) A method as in claim 33, wherein the step of suppressing unintended recipients or transmitters by the imposition of signal masking further comprises:

imposition of an origination mask.

34. (original) A method as in claim 33, wherein the step of suppressing unintended recipients or transmitters by the imposition of signal masking further comprises:

imposition of a recipient mask.

381 35. (original) A method as in claim 33, wherein the step of suppressing unintended
382 recipients or transmitters by the imposition of signal masking further comprises:
383 imposition of any combination of origination and recipient masks.

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386 36. (PREVIOUSLY PRESENTED) A method as in claim 33, wherein the step of
387 dynamically adapting the diversity capability means and said proper subsets to optimize
388 said network further comprises:
389 using signal masking to secure transmissions against unintentional, interim
390 interception and decryption by the imposition of a signal mask at origination, the
391 transmission through any number of intermediate nodes lacking said signal mask,
392 and the reception at the desired recipient which possesses the correct means for
393 removal of the signal mask.

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396 37. (original) A method as in claim 36, wherein the signal masking is shared by a proper
397 subset.

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400 38. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
401 dynamically adapting the diversity capability means and said proper subsets to optimize
402 said network further comprises:
403 heterogenous combination of a hierarchy of proper subsets, one within the other,
404 each paired with a separable subset wherein the first is a transmit uplink and the
405 second is a transmit downlink subset, such that the first subset of each pair of
406 subsets is capable of communication with the members of the second subset of
407 each pair, yet neither subset may communicate between its own members.

39. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:
using as many of the available diversity capability means as are needed for traffic between any two nodes from 1 to NumChannels, where NumChannels equals the maximal diversity capability means between said two nodes.

40. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:
using a water-filling algorithm to route traffic between an origination and destination node through any intermediate subset of nodes that has available diversity capability means capacity.

41. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic communications network, comprising:
organizing a wireless electromagnetic communications network, comprising
a set of nodes, said set further comprising,
at least a first subset of MIMO-capable nodes, each MIMO-capable node comprising:
a spatially diverse antennae array of M antennae, where $M \geq$ two, said antennae array being polarization diverse, and circularly symmetric, and providing 1-to- M RF feeds;
a transceiver for each antenna in said array, said transceiver further comprising
a Butler Mode Forming element, providing spatial signature separation with a FFT-LS algorithm, reciprocally forming a transmission with shared receiver feeds, such that the number of modes out

equals the numbers of antennae, establishing such
 as an ordered set with decreasing energy, further
 comprising:
 a dual-polarization element for splitting the
 modes into positive and negative polarities
 with opposite and orthogonal polarizations,
 that can work with circular polarizations,
 and
 a dual-polarized link CODEC;
 a transmission/reception switch comprising,
 a vector OFDM receiver element;
 a vector OFDM transmitter element;
 a LNA bank for a receive signal, said LNA
 Bank also instantiating low noise
 characteristics for a transmit signal;
 a PA bank for the transmit signal that
 receives the low noise characteristics for
 said transmit signal from said LNA bank;
 an AGC for said LNA bank and PA bank;
 a controller element for said
 transmission/reception switch enabling
 baseband link distribution of the energy over
 the multiple RF feeds on each channel to
 steer up to K_{feed} beams and nulls
 independently on each FDMA channel;
 a Frequency Translator;
 a timing synchronization element controlling
 said controller element;
 further comprising a system clock,
 a universal Time signal element;
 GPS;

472 a multimode power management element
 473 and algorithm;
 474 and,
 475 a LOs element;
 476 said vector OFDM receiver element comprising
 477 an ADC bank for downconversion of
 478 received RF signals into digital signals;
 479 a MT DEMOD element for multitone
 480 demodulation, separating the received signal
 481 into distinct tones and splitting them into 1
 482 through K_{feed} FDMA channels, said
 483 separated tones in aggregate forming the
 484 entire baseband for the transmission, said
 485 MT DEMOD element further comprising
 486 a Comb element with a multiple of 2
 487 filter capable of operating on a 128-
 488 bit sample; and,
 489 an FFT element with a 1,024 real-IF
 490 function;
 491 a Mapping element for mapping the
 492 demodulated multitone signals into a 426
 493 active receive bins, wherein
 494 each bin covers a bandwidth of 5.75
 495 MHz;
 496 each bin has an inner passband of
 497 4.26 MHz for a content envelope;
 498 each bin has an external buffer, up
 499 and down, of 745 kHz;
 500 each bin has 13 channels, CH0
 501 through CH12, each channel having
 502 320 kHz and 32 tones, T0 through

503 T31, each tone being 10 kHz, with
 504 the inner 30 tones being used
 505 information bearing and T0 and T31
 506 being reserved;
 507 each signal being 100 μ s, with 12.5
 508 μ s at each end thereof at the front
 509 and rear end thereof forming
 510 respectively a cyclic prefix and
 511 cyclic suffix buffer to punctuate
 512 successive signals;
 513 a MUX element for timing modification
 514 capable of element-wise multiplication
 515 across the signal, which halves the number
 516 of bins and tones but repeats the signal for
 517 high-quality needs;
 518 a link CODEC, which separates each FDMA
 519 channel into 1 through M links, further
 520 comprising
 521 a SOVA bit recovery element;
 522 an error coding element;
 523 an error detection element;
 524 an ITI remove element;
 525 a tone equalization element;
 526 and,
 527 a package fragment retransmission
 528 element;
 529 a multilink diversity combining element,
 530 using a multilink Rx weight adaptation
 531 algorithm for Rx signal weights $\mathbf{W}(k)$

532 to adapt transmission gains $\mathbf{G}(k)$ for each
 533 channel k ;
 534 an equalization algorithm, taking the signal
 535 from said multilink diversity combining
 536 element and controlling a delay removal
 537 element;
 538 said delay removal element separating signal
 539 content from imposed pseudodelay and
 540 experienced environmental signal delay, and
 541 passing the content-bearing signal to a
 542 symbol-decoding element;
 543 said symbol-decoding element for
 544 interpretation of the symbols embedded in
 545 the signal, further comprising:
 546 an element for delay gating;
 547 a QAM element; and
 548 a PSK element;
 549 said vector OFDM transmitter element comprising:
 550 a DAC bank for conversion of digital signals
 551 into RF signals for transmission;
 552 a MT MOD element for multitone
 553 modulation, combining and joining the
 554 signal to be transmitted from 1 through K_{feed}
 555 FDMA channels, said separated tones in
 556 aggregate forming the entire baseband for
 557 the transmission, said MT MOD element
 558 further comprising
 559 a Comb element with a multiple of 2
 560 filter capable of operating on a 128-
 561 bit sample; and,

562 an IFFT element with a 1,024 real-IF
563 function;
564 a Mapping element for mapping the
565 modulated multitone signals from 426
566 active transmit bins, wherein
567 each bin covers a bandwidth of 5.75
568 MHz;
569 each bin has an inner passband of
570 4.26 MHz for a content envelope;
571 each bin has an external buffer, up
572 and down, of 745 kHz;
573 each bin has 13 channels, CH0
574 through CH12, each channel having
575 320 kHz and 32 tones, T0 through
576 T31, each tone being 10 kHz, with
577 the inner 30 tones being used
578 information bearing and T0 and T31
579 being reserved;
580 each signal being-100 μ s, with 12.5
581 μ s at each end thereof at the front
582 and rear end thereof forming
583 respectively a cyclic prefix and
584 cyclic suffix buffer to punctuate
585 successive signals;
586 a MUX element for timing modification
587 capable of element-wise multiplication
588 across the signal, which halves the number
589 of bins and tones but repeats the signal for
590 high-quality needs;

591 a symbol-coding element for embedding the
 592 symbols to be interpreted by the receiver in
 593 the signal, further comprising:
 594 an element for delay gating;
 595 a QAM element; and
 596 a PSK element;
 597 a link CODEC, which aggregates each
 598 FDMA channel from 1 through M links,
 599 further comprising
 600 a SOVA bit recovery element;
 601 an error coding element;
 602 an error detection element;
 603 an ITI remove element;
 604 a tone equalization element;
 605 and,
 606 a package fragment retransmission
 607 element;
 608 a multilink diversity distribution element,
 609 using a multilink Tx weight adaptation
 610 algorithm for Tx signal weights to adapt
 611 transmission gains $\mathbf{G}(k)$ for each channel
 612 k , such that $\mathbf{g}(q;k) \propto \mathbf{w}^*(q;k)$;
 613 a TCM codec;
 614 a pilot symbol CODEC element that integrates with said
 615 FFT-LS algorithm a link separation, a pilot and data signal
 616 elements sorting, a link detection, multilink combination,
 617 and equalizer weight calculation operations;
 618 means for diversity transmission and reception,
 619 and,

620 means for input and output from and to a non-radio
621 interface;
622
623 linking said set of nodes ~~being deployed~~ according to design rules that
624 favor ~~prefer meeting~~ the following criteria:
625 subdividing said set of nodes ~~further comprising into~~ two or more
626 proper subsets of nodes, with a first proper subset being ~~the a~~
627 transmit uplink / receive downlink subset, and a second proper
628 subset being ~~the a~~ transmit downlink / receive uplink subset;
629
630 allowing each node in said set of nodes to simultaneously belong
631 ~~belonging to no more~~ only as many transmitting uplink or
632 receiving uplink subsets ~~than~~ as it has diversity capability means;
633
634 allowing each node in a the transmit uplink / receive downlink
635 subset ~~has no more to simultaneously link to only as many~~ nodes
636 with which it will hold time and frequency coincident
637 communications in its field of view, ~~than~~ as it has diversity
638 capability means;
639
640 allowing each node in a the transmit downlink / receive uplink
641 subset ~~has no more to simultaneously link to only as many~~ nodes
642 with which it will hold time and frequency coincident
643 communications in its field of view, ~~than~~ as it has diversity
644 capability means;
645 allowing each member of a the transmit uplink / receive downlink
646 subset ~~cannot hold to engage in simultaneous~~ time and frequency
647 coincident communications with any other member of that transmit
648 uplink / receive downlink subset only if both that other member
649 also belongs to a different proper subset and the communication is
650 between different proper subsets;

651 and,
652 allowing each member of a the transmit downlink / receive uplink
653 subset ~~cannot hold~~ to engage in simultaneous, time and frequency
654 coincident communications with any other member of that transmit
655 downlink / receive uplink subset only if both that other member
656 also belongs to a different proper subset and the communication is
657 between different proper subsets;

658
659 transmitting, in said wireless electromagnetic communications network,
660 independent information from each node belonging to a first proper subset, to one
661 or more receiving nodes belonging to a second proper subset that are viewable
662 from the transmitting node;

663
664 processing independently, in said wireless electromagnetic communications
665 network, at each receiving node belonging to said second proper subset,
666 information transmitted from one or more nodes belonging to said first proper
667 subset;

668
669 and,

670
671 designing the network such that substantially reciprocal symmetry exists for the
672 uplink and downlink channels by,

673 if the received interference is spatially white in both link directions, setting

674 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,

675 where $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights
676 used in the downlink;

677
678 but if the received interference is not spatially white in both link
679 directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to satisfy:

$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

using any standard communications protocol, including TDD, FDD, simplex,

and,

optimizing the network by dynamically adapting the diversity capability means between nodes of said transmitting and receiving subsets.

42. (CANCELLED)

43. (CANCELLED)

44. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

optimizing at each node acting as a receiver the receive weights using a MMSE technique to adjust the multitone transmissions between it and other nodes.

705 45. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
706 dynamically adapting the diversity capability means and said proper subsets to optimize
707 said network further comprises:
708 optimizing at each node acting as a receiver the receive weights using the MAX
709 maximum SINR to adjust the multitone transmissions between it and other nodes.
710
711

712 46. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
713 dynamically adapting the diversity capability means and said proper subsets to optimize
714 said network further comprises:
715 optimizing at each node acting as a receiver the receive weights, then optimizing
716 the transmit weights at that node by making them proportional to the receive
717 weights, and then optimizing the transmit gains for that node by a max-min
718 criterion for the link capacities for that node at that particular time.
719
720

721 47. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
722 dynamically adapting the diversity capability means and said proper subsets to optimize
723 said network further comprises:
724 including, as part of said network, one or more network controller elements that
725 assist in tuning local node's maximum capacity criteria and link channel diversity
726 usage to network constraints.
727
728

729 48. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
730 dynamically adapting the diversity capability means and said proper subsets to optimize
731 said network further comprises:

characterizing the channel response vector $\mathbf{a}_1(f, t; n_2, n_1)$ by the observed
(possibly time-varying) azimuth and elevation $\{\theta_1(t; n_2, n_1),$
 $\varphi_1(f, t; n_2, n_1)\}$ of node n_2 observed at n_1 .

49. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
dynamically adapting the diversity capability means and said proper subsets to optimize
said network further comprises:

characterizing the channel response vector $\mathbf{a}_1(f, t; n_2, n_1)$ as a superposition of
direct-path and near-field reflection path channel responses, e.g., due to scatterers
in the vicinity of n_1 , such that each element of $\mathbf{a}_1(f, t; n_2, n_1)$ can be modeled
as a random process, possibly varying over time and frequency.

50. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
dynamically adapting the diversity capability means and said proper subsets to optimize
said network further comprises:

presuming that $\mathbf{a}_1(f, t; n_2, n_1)$ and $\mathbf{a}_1(f, t; n_1, n_2)$ can be substantively
time invariant over significant time durations, e.g., large numbers of OFDM
symbols or TDMA time frames, and inducing the most significant frequency and
time variation by the observed timing and carrier offset on each link.

51. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
dynamically adapting the diversity capability means and said proper subsets to optimize
said network further comprises:

in such networks, e.g., TDD networks, wherein the transmit and receive
 frequencies are identical ($f_{21}(k) = f_{12}(k) = f(k)$) and the transmit and
 receive time slots are separated by short time intervals ($t_{21}(l) = t_{12}(l) + \Delta_{21}$
 $\approx t(l)$), and $\mathbf{H}_{21}(k, l)$ and $\mathbf{H}_{12}(k, l)$ become substantively reciprocal,
 such that the subarrays comprising $\mathbf{H}_{21}(k, l)$ and $\mathbf{H}_{12}(k, l)$ satisfy
 $\mathbf{H}_{21}(k, l; n_2, n_1) \approx \delta_{21}(k, l; n_1, n_2) \mathbf{H}_{12}^T(k, l; n_1, n_2)$, where
 $\delta_{21}(k, l; n_1, n_2)$ is a unit-magnitude, generally nonreciprocal scalar,
 equalizing the observed timing offsets, carrier offsets, and phase offsets, such that
 $\lambda_{21}(n_2, n_1) \approx \lambda_{12}(n_1, n_2)$, $\tau_{21}(n_2, n_1) \approx \tau_{12}(n_1, n_2)$, and
 $\nu_{21}(n_1, n_2) \approx \nu_{12}(n_1, n_2)$, by synchronizing each node to an external,
 universal time and frequency standard, obtaining $\delta_{21}(k, l; n_2, n_1) \approx 1$,
 and establishing network channel response as truly reciprocal $\mathbf{H}_{21}(k, l) \approx$
 $\mathbf{H}_{12}^T(k, l)$.

52.(original) A method as in claim 51, wherein the synchronization of each node is to
 Global Position System Universal Time Coordinates (GPS UTC).

53. (original) A method as in claim 51, wherein the synchronization of each node is to a
 network timing signal.

54. (original) A method as in claim 51, wherein the synchronization of each node is to a combination of Global Position System Universal Time Coordinates (GPS UTC) and a network timing signal.

55. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of dynamically adapting the diversity capability means and said proper subsets to optimize said network further comprises:

for such parts of the network where the internode channel responses possess substantive multipath, such that $\mathbf{H}_{21}(k, l; n_2, n_1)$ and $\mathbf{H}_{12}(k, l; n_1, n_2)$ have rank greater than unity, making the channel response substantively reciprocal by:

(1) forming uplink and downlink transmit signals using the matrix formula

$$\mathbf{s}_1(k, l; n_1) = \mathbf{G}_1(k, l; n_1) \mathbf{d}_1(k, l; n_1)$$

$$\mathbf{s}_2(k, l; n_1) = \mathbf{G}_2(k, l; n_2) \mathbf{d}_2(k, l; n_2);$$

(2) reconstructing the data intended for each receive node using the matrix formula

$$\mathbf{y}_1(k, l; n_1) = \mathbf{W}_1^H(k, l; n_1) \mathbf{x}_1(k, l; n_1)$$

$$\mathbf{y}_2(k, l; n_2) = \mathbf{W}_2^H(k, l; n_2) \mathbf{x}_2(k, l; n_2);$$

(3) developing combiner weights that $\{\mathbf{w}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{w}_2(k, l; n_1, n_2)\}$ that substantively null data intended for recipients during the symbol recovery operation, such that for $n_1 \neq n_2$:

804 (4) developing distribution weights $\{\mathbf{g}_1(k, l; n_2, n_1)\}$ and
805 $\{\mathbf{g}_2(k, l; n_1, n_2)\}$ that perform equivalent substantive nulling
806 operations during transmit signal formation operations;

807 (5) scaling distribution weights to optimize network capacity and/or power
808 criteria, as appropriate for the specific node topology and application
809 addressed by the network;

810 (6) removing residual timing and carrier offset remaining after recovery of
811 the intended network data symbols;

812 and

813 (7) encoding data onto symbol vectors based on the end-to-end SINR
814 obtainable between each transmit and intended recipient node, and
815 decoding that data after symbol recovery operations, using channel coding
816 and decoding methods develop in prior art.

817

818 56. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
819 adapting the diversity capability means and said proper subsets to optimize said network
820 further comprises:

821 forming substantively nulling combiner weights using an FFT-based least-squares
822 algorithms that adapt $\{\mathbf{w}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{w}_2(k, l; n_1, n_2)\}$ to
823 values that minimize the mean-square error (MSE) between the combiner output
824 data and a known segment of transmitted pilot data;

825 applying the pilot data to an entire OFDM symbol at the start of an adaptation
826 frame comprising a single OFDM symbol containing pilot data followed by a
827 stream of OFDM symbols containing information data;

828 wherein the pilot data transmitted over the pilot symbol is preferably given by

$$p_1(k; n_2, n_1) = d_1(k, 1; n_2, n_1)$$

$$= p_{01}(k) p_{21}(k; n_2) p_{11}(k; n_1)$$

$$p_2(k; n_1, n_2) = d_2(k, 1; n_1, n_2)$$

$$= p_{02}(k) p_{12}(k; n_1) p_{22}(k; n_2)$$

such that the “pseudodelays” $\delta_1(n_1)$ and $\delta_2(n_2)$ are unique to each transmit node (in small networks), or provisioned at the beginning of communication with any given recipient node (in which case each will be a function of n_1 and n_2), giving each pilot symbol a pseudorandom component;

maintaining minimum spacing between any pseudodelays used to communicate with a given recipient node that is larger than the maximum expected timing offset observed at that recipient node, said spacing should also being an integer multiple of $1/K$, where K is the number of tones used in a single FFT-based LS algorithm;

and if K is not large enough to provide a sufficiency of pseudodelays, using additional OFDM symbols for transmission of pilot symbols, either lengthening the effective value of K , or reducing the maximum number of originating nodes transmitting pilot symbols over the same OFDM symbol;

also providing K large enough to allow effective combiner weights to be constructed from the pilot symbols alone;

then obtaining the remaining information-bearing symbols, which are the uplink and downlink data symbols provided by prior encoding, encryption, symbol randomization, and channel preemphasis stages, in the adaptation frame, by using

$$d_1(k, l; n_2, n_1) = p_1(k; n_2, n_1) d_{01}(k, l; n_2, n_1)$$

$$d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2);$$

removing at the recipient node, first the pseudorandom pilot components from the received data by multiplying each tone and symbol by the pseudorandom components of the pilot signals, using

$$d_2(k, l; n_1, n_2) = p_2(k; n_1, n_2) d_{02}(k, l; n_1, n_2)$$

$$\mathbf{x}_{02}(k, l; n_2) = c_{01}(k; n_2) \mathbf{x}_2(k, l; n_2);$$

thereby transforming each authorized and intended pilot symbol for the recipient node into a complex sinusoid with a slope proportional to the sum of the pseudodelay used during the pilot generation procedure, and the actual observed timing offset for that link, and leaving other, unauthorized pilot symbols, and symbols intended for other nodes in the network, untransformed and so appearing as random noise at the recipient node.

57. (PREVIOUSLY PRESENTED) A method as in claim 55, wherein the FFT-Least Squares algorithm further comprises:

using a pilot symbol, which is multiplied by a unit-norm FFT window function;
passing that result to a QR decomposition algorithm and computing orthogonalized data $\{\mathbf{q}(k)\}$ and an upper-triangular Cholesky statistics matrix \mathbf{R} ;

871 then multiplying each vector element of $\{\mathbf{q}(k)\}$ by the same unit-norm FFT
 872 window function and passing it through a zero-padded inverse Fast Fourier
 873 Transform (IFFT) with output length PK , with padding factor P to form
 874 uninterpolated, spatially whitened processor weights $\{\mathbf{u}(m)\}$, where lag index
 875 m is proportional to target pseudodelay $\delta(m) = m/PK$;
 876 then using the spatially whitened processor weights to estimate the mean-square-
 877 error (MSE) obtaining for a signal received at each target pseudodelay,
 878 $\varepsilon(m) = 1 - \|\mathbf{u}(m)\|^2$, yielding a detection statistic (pseudodelay indicator
 879 function), with an extreme at IFFT lags commensurate with the observed
 880 pseudodelay and designed to minimize interlag interference between pilot signal
 881 features in the pseudodelay indicator function;
 882 using an extremes-finding algorithm to detect each extreme;
 883 estimating the location of the observed pseudodelays to sub-lag accuracy;
 884 determining additional ancillary statistics;
 885 selecting the extremes beyond a designated MSE threshold;
 886 interpolating spatially whitened weights \mathbf{U} from weights near the extremes;
 887 using the whitened combiner weights \mathbf{U} to calculate both unwhitened combiner
 888 weights $\mathbf{W} = \mathbf{R}^{-1}\mathbf{U}$ to be used in subsequent data recovery operations, and to
 889 estimate the received channel aperture matrix $\mathbf{A} = \mathbf{R}^H\mathbf{U}$, to facilitate ancillary
 890 signal quality measurements and fast network entry in future adaptation frames;
 891 and, lastly,
 892 using an estimated and optimized pseudodelay vector $\boldsymbol{\delta}_*$ to generate $\mathbf{c}_1(k) =$
 893 $\exp\{-j2\pi\boldsymbol{\delta}_*k\}$ (conjugate of $\{p_{11}(k; n_1)\}$ during uplink receive
 894 operations, and $\{p_{22}(k; n_2)\}$ during downlink receive operations), which is then
 895 used to remove the residual observed pseudodelay from the information bearing
 896 symbols.

897

898

899 58. (original) A method as in claim 55, wherein the pseudodelay estimation is refined
900 using a Gauss-Newton recursion using the approximation :

901
$$\exp\{-j2\pi\Delta(k-k_0)/PK\} \approx 1 -j2\pi\Delta(k-k_0)/PK.$$

902

903

904 59. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein wherein
905 dynamically adapting the diversity[capability means and said proper subsets to optimize
906 said network further comprises:

907 using the linear combiner weights provided during receive operations are
908 construct linear distribution weights during subsequent transmit operations, by
909 setting distribution weight $\mathbf{g}_1(k, l; n_2, n_1)$ proportional to
910 $\mathbf{w}_1^*(k, l; n_2, n_1)$ during uplink transmit operations, and
911 $\mathbf{g}_2(k, l; n_1, n_2)$ proportional to $\mathbf{w}_2^*(k, l; n_1, n_2)$ during downlink
912 transmit operations; thereby making the transmit weights substantively nulling
913 and thereby allowing each node to form frequency and time coincident two-way
914 links to every node in its field of view, with which it is authorized (through
915 establishment of link set and transfer of network/recipient node information) to
916 communicate.

917

918

919 60. (CURRENTLY AMENDED) A method as in claim 1, wherein the substep of
920 dynamically adapting the diversity capability means and said proper subsets to optimize
921 said network at each node in the first subset of nodes further comprises:

922 using a LEGO implementation element and algorithm.

923

924

925 61. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
926 adapting the diversity capability means and said proper subsets to optimize said network
927 further comprises:

928 balancing the power use against capacity for each channel, link, and node, and
929 hence for the network as a whole by:

930 establishing a capacity objective $\{\beta(m)\}$ for a user 2 node receiving
931 from a user 1 node as the target to be achieved by the user 2 node;
932 solving, at the user 2 node the local optimization problem:

933
$$\min \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1, \text{ such that}$$

934
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m),$$

935 where $\pi_1(q)$ is the transmit power for link number q for the user
936 1 node,

937 $\gamma(q)$ is the signal to interference and noise ratio (SINR) seen at
938 the output of the beamformer,

939 $\mathbf{1}$ is a vector of all 1s,

940 and,

941 $\boldsymbol{\pi}_1$ is a vector whose q^{th} element is $\pi_1(q)$,

942 the aggregate set $Q(m)$ contains a set of links that are grouped
943 together for the purpose of measuring capacity flows through those
944 links;

945 using at the user 2 node the local optimization solution to moderate the
946 transmit and receive weights, and signal information, returned to [user 1
947 node;

948 and,

950 using said feedback to compare against the capacity objective $\{\beta(m)\}$
 951 and incrementally adjust the transmit power at each of the user 1 node and
 952 the user 2 node until no further improvement is perceptible.

953

954

955 62. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein dynamically
 956 adapting the diversity capability means and said proper subsets to optimize said network
 957 further comprises:

958 using the downlink objective function

$$959 \quad \min \sum_q \pi_2(q) = \mathbf{1}^T \boldsymbol{\pi}_2 \text{ such that } \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq$$

$$960 \quad \beta(m)$$

961 at each node to perform local optimization;

962 reporting the required feasibility condition,

$$963 \quad \sum_{q \in Q(m)} \pi_1(q) \leq R_1(m);$$

964 and,

965 modifying $\beta(m)$ as necessary to stay within the constraint.

966

967

968 63. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:

969 the capacity constraints $\beta(m)$ are determined in advance for each proper subset
 970 of nodes, based on known QoS requirements for each said proper subset.

971

972

973 64. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network
 974 further seeks to minimize total power in the network as suggested by

$$975 \quad \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m).$$

976

976

977 65. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network sets
978 as a target objective for the network $\{\beta(m)\}$ the QoS for the network.

979

980

981 66. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein said network sets
982 as a target objective for the network $\{\beta(m)\}$ a vector of constraints.

983

984

985 67. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the local
986 optimization problem is further defined such that:

987

988 the receive and transmit weights are unit normalized with respect to the
989 background interference autocorrelation matrix;

990

991 the local SINR is expressed as

$$\gamma(q) = \frac{P_{rt}(q, q)\pi_t(q)}{1 + \sum_{j \neq q} P_{rt}(q, j)\pi_t(j)} ;$$

992

993

994 and the weight normalization

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

996 is used to enable $D_{12}(\mathbf{W}, \mathbf{G}) = D_{21}(\mathbf{G}^*, \mathbf{W}^*)$, where $(\mathbf{W}_2, \mathbf{G}_1)$

997 and $(\mathbf{W}_1, \mathbf{G}_2)$ represent the receive and transmit weights employed by all

998 nodes in the network during uplink and downlink operations, respectively, at that

999 node, thereby allowing the uplink and downlink function to be presumed identical

1000 rather than separately computed.

1001

1002

1003 68. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:

1004 very weak constraints to the transmit powers are approximated by using a very

1005 simple approximation for $\gamma(q)$.

1006

1007

1008 69. (PREVIOUSLY PRESENTED) A method as in claim 61, for the cases wherein all

1009 the aggregate sets contain a single link and non-negligible environmental noise is present,

1010 wherein the transmit powers are computed as Perron vectors from

$$\begin{aligned} D_{21} &= \log \left(1 + \frac{1}{\rho(\mathbf{P}_{21}) - 1} \right) \\ &= \log \left(1 + \frac{1}{\rho(\mathbf{P}_{12}^T) - 1} \right); \\ &= D_{12} \end{aligned}$$

1012 and a simple power constraint is imposed upon the transmit powers.

1013

1014

1015 70. (PREVIOUSLY PRESENTED) A method as in claim 69, wherein the optimization

1016 is performed in alternating directions and repeated.

1017

1018

1019 71. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node

1020 presumes the post-beamforming interference energy remains constant for the adjustment

1021 interval and so solves

$$\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1, \text{ subject to the constraint of}$$

1023 $\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$

1024 using classic water filling arguments based on Lagrange multipliers, and then uses a
1025 similar equation for the reciprocal element of the link.

1026

1027

1028 72. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein at each node the
1029 constrained optimization problem stated in

1030 $\max_m \sum_{q \in Q(m)} \log(1 + \gamma(q)), \text{ such that}$

1031 $\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m), \gamma(q) \geq 0$

1032 is solved using the approximation

1033
$$\gamma(q) = \frac{P_{21}(q, q) \pi_1(q)}{i_2(q)}$$

1034 and the network further comprises at least one high-level network controller that controls
1035 the power constraints $R_1(m)$, and drives the network towards a max-min solution.

1036

1037

1038 73. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node:

1039 is given an initial γ_0 ;

1040 generates the model expressed in

1041 $L(\gamma, \mathbf{g}, \beta) = \mathbf{g}^T \gamma, \sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$

1042 $\mathbf{g} = \nabla_{\gamma} f(\gamma_0);$

1043 updates the new γ_{α} from

1044 $\gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta), \gamma_{\alpha} = \gamma_0 + \alpha(\gamma_* - \gamma_0);$

1045 determines a target SINR to adapt to; and,

1046 updates the transmit power for each link q according to

1047
$$\pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

1048
$$\pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2 .$$

1049

1050 74. (PREVIOUSLY PRESENTED) A method as in claim 61, for each node wherein the
1051 transmit power relationship of

1052
$$\pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

1053
$$\pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2$$

1054 is not known, that:

1055 uses a suitably long block of N samples is used to establish the relationship, where

1056 N is either 4 times the number of antennae or 128, whichever is larger;

1057 uses the result to update the receive weights at each end of the link;

1058 optimizes the local model as in

1059
$$\gamma_* = \arg \min_{\gamma} L(\gamma, \mathbf{g}, \beta)$$

1060
$$\gamma_\alpha = \gamma_0 + \alpha(\gamma_* - \gamma_0);$$

1061 and then applies

1062
$$\pi_2(q) = \gamma_\alpha i_1(q) / |h(q)|^2$$

1063
$$\pi_1(q) = \gamma_\alpha i_2(q) / |h(q)|^2 .$$

1064

1065 75. (PREVIOUSLY PRESENTED) A method as in claim 61 that, for an aggregate
1066 proper subset m :

1067 for each node within the set m, inherits the network objective function model
1068 given in

1069
$$L_m(\gamma, \mathbf{g}, \beta) = \sum_{q \in Q(m)} \mathbf{g}_q \gamma(q)$$

1070
$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m)$$

1071
$$g(q) = i_1(q)i_2(q) / |h(q)|^2 ;$$

1072 eliminates a step of matrix channel estimation, transmitting instead from
1073 that node as a single real number for each link to the other end of said link
1074 an estimate of the post beamforming interference power;
1075 and ,
1076 receives back for each link a single real number being the transmit power.

1077

1078 76. (PREVIOUSLY PRESENTED) A method as in claim 74, that for each pair of
1079 nodes assigns to the one presently possessing the most processing capability the power
1080 management computations.

1081

1082

1083 77. (PREVIOUSLY PRESENTED) A method as in claim 75 that estimates the transfer
1084 gains and the post beamforming interference power using simple least squares estimation
1085 techniques.

1086

1087

1088 78. (PREVIOUSLY PRESENTED) A method as in claim 75 that, for estimating the
1089 transfer gains and post beamforming interference power:

1090

1091 instead solves for the transfer gain h using

1092
$$y(n) = hgs(n) + \varepsilon(n);$$

1093 uses a block of N samples of data to estimate h using

$$h = \frac{\sum_{n=1}^N s^*(n)y(n)}{\sum_{n=1}^N |s(n)|^2 g}$$

obtains an estimation of residual interference power [R_ϵ] using

$$R_\epsilon = \left\langle | \epsilon(n) |^2 \right\rangle$$

$$= \frac{1}{N} \sum_{n=1}^N \left(|y(n)|^2 - |ghs(n)|^2 \right) ;$$

and,

obtains knowledge of the transmitted data symbols $s(n)$ from using remodulated symbols at the output of the codec.

1100

1101

79. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of obtaining knowledge of the transmitted data symbols $s(n)$ from using remodulated symbols at the output of the codec, the node uses the output of a property restoral algorithm used in a blind beamforming algorithm.

1106

1107

80. (PREVIOUSLY PRESENTED) A method as in claim 78 wherein, instead of obtaining knowledge of the transmitted data symbols $s(n)$ from using remodulated symbols at the output of the codec, the node uses a training sequence explicitly transmitted to train beamforming weights and asset the power management algorithms.

1112

1113

1114 81. (CURRENTLY AMENDED) A method as in claim 78 wherein, instead of
1115 obtaining knowledge of the transmitted data symbols $S(n)$ from using remodulated
1116 symbols at the output of the codec, the node uses any combination of:
1117 the output of a property restoral algorithm used in a blind beamforming algorithm;
1118 a training sequence explicitly transmitted to train beamforming weights and asset
1119 the power management algorithms;
1120 σ^2 , and,
1121 other means known to the art.

1122

1123

1124 82. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein each node
1125 incorporates a link level optimizer and a decision algorithm.

1126

1127 83. (PREVIOUSLY PRESENTED) A method as in claim 82, wherein the decision
1128 algorithm is a Lagrange multiplier technique.

1129

1130

1131 84. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the solution to

1132 $\min_{\pi_1(q)} \sum_q \pi_1(q) = \mathbf{1}^T \boldsymbol{\pi}_1$ is implemented by a penalty function technique.

1133

1134

1135 85. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty
1136 function technique:

1137 takes the derivative of $\gamma(q)$ with respect to $\boldsymbol{\pi}_1$;

1138 and,

1139 uses the Kronecker-Delta function and the weighted background noise.

1140

1141

1142 86. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty
1143 function technique neglects the noise term.

1144

1145

1146 87. (PREVIOUSLY PRESENTED) A method as in claim 84, wherein the penalty
1147 function technique normalizes the noise term to one.

1148

1149

1150 88. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the
1151 approximation uses the receive weights.

1152

1153

1154 89. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein adaptation to the
1155 target objective is performed in a series of measured and quantized descent and ascent
1156 steps.

1157

1158 90. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein the adaptation to
1159 the target objective is performed in response to information stating the vector of change.

1160

1161

1162 91. (PREVIOUSLY PRESENTED) A method as in claim 61, which uses the log linear
1163 mode

1164
$$\beta_q \approx \log \left(\frac{a \pi_1(q) + a_0}{b \pi_1(q) + b_0} \right) = \hat{\beta}_q(\pi_1(q))$$

1165 and the inequality characterization $\hat{\beta}_q(\pi_1(q)) \geq \beta$ to solve the approximation
1166 problem with a simple low dimensional linear program.

1167

1168

1169 92. (PREVIOUSLY PRESENTED) A method as in claim 61, develops the local mode
1170 by matching function values and gradients between the current model and the actual
1171 function.
1172
1173
1174 93. (PREVIOUSLY PRESENTED) A method as in claim 61, which develops the model
1175 as a solution to the least squares fit, evaluated over several points.
1176
1177
1178 94. (PREVIOUSLY PRESENTED) A method as in claim 61, which reduces the cross-
1179 coupling effect by allowing only a subset of links to update at any one particular time,
1180 wherein the subset members are chosen as those which are more likely to be isolated
1181 from one another.
1182
1183
1184 95. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein:
1185 the network further comprises a network controller element;
1186 said network controller element governs a subset of the network;
1187 said network controller element initiates, monitors, and changes the target
1188 objective for that subset;
1189 said network controller communicates the target objective to each node in that
1190 subset;
1191 and,
1192 receives information from each node concerning the adaptation necessary to meet
1193 said target objective.
1194
1195
1196 96. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein said network
1197 further records the scalar and history of the increments and decrements ordered by the
1198 network controller.
1199

1200

1201 97. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a
1202 target objective may be a power constraint.

1203

1204

1205 98. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a
1206 target objective may be a capacity maximization subject to a power constraint.

1207

1208

1209 99. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a
1210 target objective may be a power minimization subject to the capacity attainment to the
1211 limit possible over the entire network.

1212

1213

1214 100. (PREVIOUSLY PRESENTED) A method as in claim 61, wherein for any subset, a
1215 target objective may be a power minimization at each particular node in the network
1216 subject to the capacity constraint at that particular node.

1217

1218

1219 101. (CURRENTLY AMENDED) A wireless electromagnetic communications
1220 network, comprising:

1221 a wireless electromagnetic communications network, comprising

1222 a set of nodes, said set further comprising,

1223 at least a first subset wherein each node is MIMO-capable,

1224 comprising:

1225 a spatially diverse antennae array of M antennae, where M

1226 \geq one,

1227 a transceiver for each antenna in said array,

1228 means for digital signal processing,

1229 means for coding and decoding data and symbols,

1230 means for diversity transmission and reception,

1231 and,
1232 means for input and output from and to a non-radio
1233 interface;
1234 said set of nodes further comprising one or more proper subsets of nodes,
1235 being at least one transmitting and at least one receiving subset, with said
1236 transmitting and receiving subsets having a topological arrangement
1237 whereby:
1238 each node in a transmitting subset has no more nodes with which it
1239 will simultaneously communicate in its field of view, than it has
1240 number of antennae;
1241 each node in a receiving subset has no more nodes with which it
1242 will simultaneously communicate in its field of view, than it can
1243 steer independent nulls to;
1244 and,
1245 each member of a non-proper subset cannot communicate with any
1246 other member of its non-proper subset;
1247 means for transmitting independent information from each node in a first non-
1248 proper subset to one or more receiving nodes belonging to a second non-proper
1249 subset that are viewable from the transmitting node;
1250 means for processing independently information transmitted to a receiving node
1251 in a second non-proper subset from one or more nodes in a first non-proper subset
1252 is independently by the receiving node;
1253 and,
1254 means for optimizing the network by dynamically adapting the means for diversity
1255 transmission and reception between nodes of said transmitting and receiving subsets.
1256
1257
1258 102. (PREVIOUSLY PRESENTED) An apparatus as in claim 101, further
1259 comprising means for scheduling according to a Demand-Assigned, Multiple-Access
1260 algorithm.
1261

1262

1263 103. (CURRENTLY AMENDED) An apparatus as in claim 101, further comprising a
1264 LEGO adaptation-element for each node in said first subset ~~a LEGO adaptation-element~~.

1265

1266

1267 104. (CURRENTLY AMENDED) An apparatus as in claim 101, further comprising:
1268 a LEGO adaptation-element for each node in said first subset ~~a LEGO adaptation-~~
1269 ~~element~~; and,
1270 one or more network controllers.

1271

1272

1273 105. (PREVIOUSLY PRESENTED) A method as in claim 1, wherein the step of
1274 dynamically adapting the diversity capability means and said proper subsets to optimize
1275 said network further comprises:

1276 matching each transceiver's degrees of freedom (DOF) to the nodes in the
1277 possible link directions;
1278 equalizing those links to provide node-equivalent uplink and downlink capacity.

1279

1280

1281 106. (original) A method as in claim 105, further comprising, after the DOF matching:
1282 assigning asymmetric transceivers to reflect desired capacity weighting;
1283 adapting the receive weights to form a solution for multipath resolutions;
1284 employing data and interference whitening as appropriate to the local conditions;
1285 and,
1286 using retrodirective transmission gains during subsequent transmission operations.

1287

1288

1289 107. (original) A method as in claim 105, wherein the receive weights are matched to the
1290 nodes in the possible link directions.

1291

1292

1293 108. (CURRENTLY AMENDED) A method for optimizing a wireless electromagnetic
1294 communications network, comprising:

1295 organizing a wireless electromagnetic communications network, comprising
1296 a set of nodes, said set of nodes further comprising,

1297 at least a first subset wherein each node is MIMO-capable,
1298 comprising:

1299 an antennae array of M antennae, where $M \geq$ one,

1300 a transceiver for each antenna in said spatially diverse
1301 antennae array,

1302 means for digital signal processing to convert analog radio
1303 signals into digital signals and digital signals into analog
1304 radio signals,

1305 means for coding and decoding data, symbols, and control
1306 information into and from digital signals,

1307 diversity capability means for transmission and reception of
1308 said analog radio signals;

1309 and,

1310 means for input and output from and to a non-radio
1311 interface for digital signals;

1312 linking said set of nodes ~~being deployed~~ according to design rules that
1313 favor ~~prefer meeting~~ the following criteria:

1314
1315 subdividing said set of nodes ~~further comprising~~ into two or more
1316 proper subsets of nodes, with a first proper subset being ~~the~~ a
1317 transmit uplink / receive downlink subset, and a second proper
1318 subset being ~~the~~ a transmit downlink / receive uplink subset;

1319
1320 allowing each node in said set of nodes to simultaneously belong
1321 belonging to ~~no more~~ up to as many transmitting uplink or
1322 receiving uplink subsets ~~than~~ as it has diversity capability means;

1324 allowing each node in a the transmit uplink / receive downlink
1325 subset ~~has no more~~ to simultaneously link to up to as many nodes
1326 with which it will hold time and frequency coincident
1327 communications in its field of view, ~~than~~ as it has diversity
1328 capability means;

1329
1330 allowing each node in a the transmit downlink / receive uplink
1331 subset ~~has no more~~ to simultaneously link to up to as many nodes
1332 with which it will hold time and frequency coincident
1333 communications in its field of view, ~~than~~ as it has diversity
1334 capability means;

1335
1336 allowing each member of a the transmit uplink / receive downlink
1337 subset ~~cannot hold~~ to engage in simultaneous time and frequency
1338 coincident communications with any other member of that transmit
1339 uplink / receive downlink subset only if both that other member
1340 also belongs to a different proper subset and the communication is
1341 between different proper subsets;

1342 and,

1343 allowing each member of a transmit downlink / receive uplink
1344 subset ~~cannot hold~~ to engage in simultaneous time and frequency
1345 coincident communications with any other member of that transmit
1346 downlink / receive uplink subset only if both that other member
1347 also belongs to a different proper subset and the communication is
1348 between different proper subsets;

1349 transmitting, in said wireless electromagnetic communications network,
1350 independent information from each node belonging to a first proper subset, to one
1351 or more receiving nodes belonging to a second proper subset that are viewable
1352 from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;

optimizing at the local level for each node for the channel capacity D_{21} according to

$D_{21} = \max \beta$ such that

$$\beta \leq \sum_{q \in U(m)} \sum_k \log(1 + \gamma(k, q)),$$

$$\gamma(k, q) \geq 0,$$

$$\sum_m R_1(m) \leq R,$$

$$\pi_1(k, q) \geq 0,$$

$$\sum_{q \in U(m)} \sum_k \pi_1(k, q) \leq R_1(m)$$

solving first the reverse link power control problem; then treating the forward link problem in an identical fashion, substituting the subscripts 2 for 1 in said equation;

and,

dynamically adapting the diversity capability means and said proper subsets to optimize said network.

109. (PREVIOUSLY PRESENTED) A method as in claim 108, further comprising:

for each aggregate subset m , attempting to achieve the given capacity objective, β , as described in

1374 $\min_{\pi_r(q)} \sum_{q \in Q(m)} \pi_r(q),$ such that

1375 $\beta = \sum_{q \in Q(m)} \log(1 + \gamma(q))$

1376 by:

1377 (1) optimizing the receive beamformers, using simple MMSE processing, to
1378 simultaneously optimize the SINR;

1379 (2) based on the individual measured SINR for each q index, attempt to
1380 incrementally increase or lower its capacity as needed to match the current target;
1381 and,

1382 (3) stepping the power by a quantized small step in the appropriate direction;

1383 then,

1384 when all aggregate sets have achieved the current target capacity, then the
1385 network can either increase the target capacity β , or add additional users to
1386 exploit the now-known excess capacity.

1387

1388

1389 110. (PREVIOUSLY PRESENTED) A method as in claim 107, wherein the network
1390 optimizes for QoS and not diversity capability means capacity.

1391

1392 111. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein:

1393 said network controller adds, drops, or changes the target capacity for any node in
1394 the set the network controller controls.

1395

1396

1397 112. (PREVIOUSLY PRESENTED) A method as in claim 95, wherein:

1398 said network controller may, either in addition to or in replacement for altering β ,

1399 add, drop, or change channels between nodes, frequencies, coding, security, or

1400 protocols, polarizations, or traffic density allocations usable by a particular node
1401 or channel.

1402

1403

1404 113. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications
1405 network, comprising:

1406 a set of nodes, said set further comprising,

1407 at least a first subset wherein each node is MIMO-capable,
1408 comprising:

1409 a spatially diverse antennae array of M antennae, where M

1410 \geq one,

1411 a transceiver for each antenna in said array,

1412 means for digital signal processing,

1413 means for coding and decoding data and symbols,

1414 means for diversity transmission and reception,

1415 pilot symbol coding & decoding element

1416 timing synchronization element

1417 and,

1418 means for input and output from and to a non-radio

1419 interface;

1420 said set of nodes further comprising two or more proper subsets of nodes,

1421 there being at least one transmitting and at least one receiving subset, with

1422 said transmitting and receiving subsets subset having a diversity

1423 arrangement whereby:

1424 each node in a transmitting subset has no more nodes with which it

1425 will simultaneously communicate in its field of view, than it has

1426 number of antennae;

1427 each node in a receiving subset has no more nodes with which it

1428 will simultaneously communicate in its field of view, than it can

1429 steer independent nulls to;

1430 and,

1431 each member of a non-proper subset cannot communicate with any
 1432 other member of its non-proper subset over identical diversity
 1433 channels;

1434 a LEGO adaptation element and algorithm;

1435 a network controller element and algorithm;

1436 whereby each node in a first non-proper subset transmits independent information
 1437 to one or more receiving nodes belonging to a second non-proper subset that are
 1438 viewable from the transmitting node;

1439 each receiving node in said second non-proper subset processes independently
 1440 information transmitted to a from one or more nodes in a first non-proper subset is
 1441 independently by the receiving node;

1442 each node uses means to minimize SINR between nodes transmitting and
 1443 receiving information;

1444 the network is designed such that substantially reciprocal symmetry exists for the
 1445 uplink and downlink channels by,

1446 if the received interference is spatially white in both link directions, setting

1447 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,

1448 where $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights used
 1449 in the downlink;

1450

1451 but if the received interference is not spatially white in both link

1452 directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to satisfy:

1453
$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

1454
$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

1455

1456 the network uses any standard communications protocol;
1457 and,
1458 the network is optimized by dynamically adapting the means for diversity
1459 transmission and reception between nodes of said transmitting and receiving
1460 subsets.
1461
1462
1463 114. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications
1464 network as in claim 113:
1465 wherein each node may further comprise a Butler Mode Forming element, to
1466 enable said node to ratchet the number of active antennae for a particular uplink
1467 or downlink operation up or down.
1468
1469
1470 115. (PREVIOUSLY PRESENTED) A wireless electromagnetic communications
1471 network as in claim 101:
1472 incorporating a dynamics-resistant multitone element.
1473
1474
1475 116. (original) The use of a method as described in claim 1 for fixed wireless
1476 electromagnetic communications.
1477
1478 117. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1479 for fixed wireless electromagnetic communications.
1480
1481 118. (original) The use of a method as described in claim 1 for mobile wireless
1482 electromagnetic communications.
1483
1484 119. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1485 for mobile wireless electromagnetic communications.
1486

1487 120. (original) The use of a method as described in claim 1 for mapping operations using
1488 wireless electromagnetic communications.
1489

1490 121. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1491 for mapping operations using wireless electromagnetic communications.
1492

1493 122. (original) The use of a method as described in claim 1 for a military wireless
1494 electromagnetic communications network.
1495

1496 123. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1497 for a military wireless electromagnetic communications network.
1498

1499 124. (original) The use of a method as described in claim 1 for a military wireless
1500 electromagnetic communications network for battlefield operations.
1501

1502 125. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1503 for a military wireless electromagnetic communications network for battlefield
1504 operations.
1505

1506 126. (original) The use of a method as described in claim 1 for a military wireless
1507 electromagnetic communications network for Back Edge of Battle Area (BEBA)
1508 operations.
1509

1510 127. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1511 for a military wireless electromagnetic communications network for Back Edge of Battle
1512 Area (BEBA) operations.
1513

1514 128. (original) The use of a method as described in claim 1 for a wireless electromagnetic
1515 communications network for intruder detection operations.
1516

1517 129. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1518 for a wireless electromagnetic communications network for intruder detection operations.
1519

1520 130. (original) The use of a method as described in claim 1 for a wireless electromagnetic
1521 communications network for logistical intercommunications.
1522

1523 131. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1524 for a wireless electromagnetic communications network for logistical
1525 intercommunications.
1526

1527 132. (original) The use of a method as described in claim 1 in a wireless electromagnetic
1528 communications network for self-filtering spoofing signals.
1529

1530 133. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1531 for a wireless electromagnetic communications network for self-filtering spoofing
1532 signals.
1533

1534 134. (original) The use of a method as described in claim 1 in a wireless
1535 electromagnetic communications network for airborne relay over the horizon.
1536

1537 135. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1538 for a wireless electromagnetic communications network for airborne relay over the
1539 horizon.
1540

1541 136. (original) The use of a method as described in claim 1 in a wireless electromagnetic
1542 communications network for traffic control.
1543

1544 137. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further
1545 comprising the use thereof for air traffic control.
1546

1547 138. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further
1548 comprising the use thereof for ground traffic control.
1549

1550 139. (PREVIOUSLY PRESENTED) The use of a method as in claim 1, further
1551 comprising the use thereof for a mixture of ground and air traffic control.
1552

1553 140. (PREVIOUSLY PRESENTED) The use of an apparatus as described in claim 101
1554 for a wireless electromagnetic communications network for traffic control.
1555

1556 141. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further
1557 comprising the use thereof for air traffic control
1558

1559 142. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further
1560 comprising the use thereof for ground traffic control.
1561

1562 143. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101, further
1563 comprising the use thereof for a mixture of ground and air traffic control.
1564

1565 144. (original) The use of a method as in claim 1 in a wireless electromagnetic
1566 communications network for emergency services.
1567

1568 145. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1569 wireless electromagnetic communications network for emergency services.
1570

1571 146. (original) The use of a method as in claim 1 in a wireless electromagnetic
1572 communications network for shared emergency communications without interference.
1573

1574 147. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1575 wireless electromagnetic communications network for shared emergency
1576 communications without interference.
1577

1578 148. (original) The use of a method as in claim 1 in a wireless electromagnetic
1579 communications network for positioning operations without interference.
1580

1581 149. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1582 wireless electromagnetic communications network for positioning operations without
1583 interference.
1584

1585 150. (original) The use of a method as in claim 1 in a wireless electromagnetic
1586 communications network for high reliability networks requiring graceful degradation
1587 despite environmental conditions or changes..
1588

1589 151. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1590 wireless electromagnetic communications network for high reliability networks requiring
1591 graceful degradation despite environmental conditions or changes..
1592

1593 152. (original) The use of a method as in claim 1 in a wireless electromagnetic
1594 communications network for a secure network requiring assurance against unauthorized
1595 intrusion.
1596

1597 153. (original) The use of a method as in claim 1 in a wireless electromagnetic
1598 communications network for a secure network requiring message end-point assurance.
1599

1600 154. (original) The use of a method as in claim 1 in a wireless electromagnetic
1601 communications network for a secure network requiring assurance against unauthorized
1602 intrusion and message end-point assurance.
1603

1604 155. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1605 wireless electromagnetic communications network for a secure network requiring
1606 assurance against unauthorized intrusion.
1607

1608 156. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1609 wireless electromagnetic communications network for a secure network requiring
1610 message end-point assurance.
1611

1612 157. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 In a
1613 wireless electromagnetic communications network for a secure network requiring
1614 assurance against unauthorized intrusion and message end-point assurance.
1615
1616

1617 158. (original) The use of a method as in claim 1 in a cellular mobile radio service.
1618

1619 159. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1620 cellular mobile radio service.
1621

1622 160. (original) The use of a method as in claim 1 in a personal communication service.
1623

1624 161. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1625 personal communication service.
1626

1627 162. (original) The use of a method as in claim 1 in a private mobile radio service.
1628

1629 163. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a private
1630 mobile radio service.
1631

1632 164. (original) The use of a method as in claim 1 in a wireless LAN.
1633

1634 165. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1635 wireless LAN.
1636

1637 166. (original) The use of a method as in claim 1 in a fixed wireless access service.
1638

1639 167. (currently amended) The use of an apparatus as in claim 50[101] in a fixed wireless
1640 access service.
1641
1642 168. (original) The use of a method as in claim 1 in a broadband wireless access service.
1643
1644 169. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1645 broadband wireless access service.
1646
1647 170. (original) The use of a method as in claim 1 in a municipal area network.
1648
1649 171. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a
1650 municipal area network.
1651
1652 172. (original) The use of a method as in claim 1 in a wide area network.
1653
1654 173. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in a wide
1655 area network.
1656
1657 174. (original) The use of a method as in claim 1 in wireless backhaul.
1658
1659 175. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless
1660 backhaul.
1661
1662 176. (original) The use of a method as in claim 1 in wireless backhaul.
1663
1664 177. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless
1665 backhaul.
1666
1667 178. (original) The use of a method as in claim 1 in wireless SONET.
1668

179. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless SONET.

180-181. (CANCELLED)

182. (original) The use of a method as in claim 1 in wireless Telematics.

183. (PREVIOUSLY PRESENTED) The use of an apparatus as in claim 101 in wireless Telematics.

184. (NEW) An apparatus as in claim 101, wherein the means for digital signal processing in said first subset of MIMO-capable nodes further comprises:

- an ADC bank for downconversion of received RF signals into digital signals;
- a MT DEMOD element for multitone demodulation, separating the received signal into distinct tones and splitting them into 1 through K_{feed} FDMA channels, said separated tones in aggregate forming the entire baseband for the transmission, said MT DEMOD element further comprising
 - a Comb element with a multiple of 2 filter capable of operating on a 128-bit sample; and,
 - an FFT element with a 1,024 real-IF function;
- a Mapping element for mapping the demodulated multitone signals into a 426 active receive bins, wherein
 - each bin covers a bandwidth of 5.75MHz;
 - each bin has an inner passband of 4.26MHz for a content envelope;
 - each bin has an external buffer, up and down, of 745kHz;

1701 each bin has 13 channels, CH0 through CH12, each channel having 320
 1702 kHz and 32 tones, T0 through T31, each tone being 10kHz, with the inner
 1703 30 tones being used information bearing and T0 and T31 being reserved;
 1704 each signal being 100μs, with 12.5μs at each end thereof at the front and
 1705 rear end thereof forming respectively a cyclic prefix and cyclic suffix
 1706 buffer to punctuate successive signals;
 1707 and,
 1708 a symbol-decoding element for interpretation of the symbols embedded in the
 1709 signal.
 1710
 1711
 1712 185. (NEW) A wireless electromagnetic communications network, comprising
 1713 a set of nodes, said set further comprising,
 1714 at least a first subset of MIMO-capable nodes, each MIMO-capable node
 1715 comprising:
 1716 a spatially diverse antennae array of M antennae, where $M \geq$ two,
 1717 said antennae array being polarization diverse, and circularly
 1718 symmetric, and providing 1-to- M RF feeds;
 1719 a transceiver for each antenna in said array, said transceiver
 1720 further comprising:
 1721 a Butler Mode Forming element, providing spatial
 1722 signature separation with a FFT-LS algorithm,
 1723 reciprocally forming a transmission with shared receiver
 1724 feeds, such that the number of modes out equals the
 1725 numbers of antennae, establishing such as an ordered set
 1726 with decreasing energy, further comprising:
 1727 a dual-polarization element for splitting the
 1728 modes into positive and negative polarities with
 1729 opposite and orthogonal polarizations, that can
 1730 work with circular polarizations; and,
 1731 a dual-polarized link CODEC;

1732 a transmission/reception switch comprising:
 1733 a vector OFDM receiver element;
 1734 a vector OFDM transmitter element;
 1735 a LNA bank for a receive signal, said LNA Bank
 1736 also instantiating low noise characteristics for a
 1737 transmit signal;
 1738 a PA bank for the transmit signal that receives
 1739 the low noise characteristics for said transmit
 1740 signal from said LNA bank;
 1741 an AGC for said LNA bank and PA bank;
 1742 a controller element for said
 1743 transmission/reception switch enabling baseband
 1744 link distribution of the energy over the multiple
 1745 RF feeds on each channel to steer up to K_{feed}
 1746 beams and nulls independently on each FDMA
 1747 channel;
 1748 a Frequency Translator;
 1749 a timing synchronization element controlling said
 1750 controller element;
 1751 further comprising a system clock,
 1752 a universal Time signal element;
 1753 GPS;
 1754 a multimode power management element and
 1755 algorithm;
 1756 and,
 1757 a LOs element;
 1758 said vector OFDM receiver element comprising:
 1759 an ADC bank for downconversion of received
 1760 RF signals into digital signals;
 1761 a MT DEMOD element for multitone
 1762 demodulation, separating the received signal into

1763 distinct tones and splitting them into 1 through
 1764 K_{feed} FDMA channels, said separated tones in
 1765 aggregate forming the entire baseband for the
 1766 transmission, said MT DEMOD element further
 1767 comprising:
 1768 a Comb element with a multiple of 2
 1769 filter capable of operating on a 128-bit
 1770 sample; and,
 1771 an FFT element with a 1,024 real-IF
 1772 function;
 1773 a Mapping element for mapping the demodulated
 1774 multitone signals into a 426 active receive bins,
 1775 wherein
 1776 each bin covers a bandwidth of 5.75
 1777 MHz;
 1778 each bin has an inner passband of 4.26
 1779 MHz for a content envelope;
 1780 each bin has an external buffer, up and
 1781 down, of 745 kHz;
 1782 each bin has 13 channels, CH0 through
 1783 CH12, each channel having 320 kHz and
 1784 32 tones, T0 through T31, each tone
 1785 being 10 kHz, with the inner 30 tones
 1786 being used information bearing and T0
 1787 and T31 being reserved;
 1788 and,
 1789 each signal being 100 μs , with 12.5 μs at
 1790 each end thereof at the front and rear end
 1791 thereof forming respectively a cyclic
 1792 prefix and cyclic suffix buffer to
 1793 punctuate successive signals;

1794 a MUX element for timing modification capable
 1795 of element-wise multiplication across the signal,
 1796 which halves the number of bins and tones but
 1797 repeats the signal for high-quality needs;
 1798 a link CODEC, which separates each FDMA
 1799 channel into 1 through M links, further
 1800 comprising:
 1801 a SOVA bit recovery element;
 1802 an error coding element;
 1803 an error detection element;
 1804 an ITI remove element;
 1805 a tone equalization element;
 1806 and,
 1807 a package fragment retransmission
 1808 element;
 1809 a multilink diversity combining element, using a
 1810 multilink Rx weight adaptation algorithm for Rx
 1811 signal weights $\mathbf{W}(k)$ to adapt transmission
 1812 gains $\mathbf{G}(k)$ for each channel k ;
 1813 an equalization algorithm, taking the signal from
 1814 said multilink diversity combining element and
 1815 controlling a delay removal element;
 1816 said delay removal element separating
 1817 signal content from imposed pseudodelay
 1818 and experienced environmental signal
 1819 delay, and passing the content-bearing
 1820 signal to a symbol-decoding element;
 1821 said symbol-decoding element for
 1822 interpretation of the symbols embedded
 1823 in the signal, further comprising:

1824 an element for delay gating;
 1825 a QAM element; and
 1826 a PSK element;
 1827 said vector OFDM transmitter element comprising:
 1828 a DAC bank for conversion of digital signals into
 1829 RF signals for transmission;
 1830 a MT MOD element for multitone modulation,
 1831 combining and joining the signal to be
 1832 transmitted from 1 through K_{feed} FDMA
 1833 channels, said separated tones in aggregate
 1834 forming the entire baseband for the transmission;
 1835 said MT MOD element further comprising
 1836 a Comb element with a multiple of 2
 1837 filter capable of operating on a 128-bit
 1838 sample; and,
 1839 an IFFT element with a 1,024 real-IF
 1840 function;
 1841 a Mapping element for mapping the modulated
 1842 multitone signals from 426 active transmit bins,
 1843 wherein
 1844 each bin covers a bandwidth of 5.75
 1845 MHz;
 1846 each bin has an inner passband of 4.26
 1847 MHz for a content envelope;
 1848 each bin has an external buffer, up and
 1849 down, of 745 kHz;
 1850 each bin has 13 channels, CH0 through
 1851 CH12, each channel having 320 kHz and
 1852 32 tones, T0 through T31, each tone
 1853 being 10 kHz, with the inner 30 tones

1854 being used information bearing and T0
 1855 and T31 being reserved;
 1856 each signal being-100 μ s, with 12.5 μ s at
 1857 each end thereof at the front and rear end
 1858 thereof forming respectively a cyclic
 1859 prefix and cyclic suffix buffer to
 1860 punctuate successive signals;
 1861 a MUX element for timing modification capable
 1862 of element-wise multiplication across the signal,
 1863 which halves the number of bins and tones but
 1864 repeats the signal for high-quality needs;
 1865 a symbol-coding element for embedding the
 1866 symbols to be interpreted by the receiver in the
 1867 signal, further comprising:
 1868 an element for delay gating;
 1869 a QAM element; and
 1870 a PSK element;
 1871 a link CODEC, which aggregates each FDMA
 1872 channel from 1 through M links, further
 1873 comprising:
 1874 a SOVA bit recovery element;
 1875 an error coding element;
 1876 an error detection element;
 1877 an ITI remove element;
 1878 a tone equalization element;
 1879 and,
 1880 a package fragment retransmission
 1881 element;
 1882 a multilink diversity distribution element, using a
 1883 multilink Tx weight adaptation algorithm for Tx
 1884 signal weights to adapt transmission gains

1885 $G(k)$ for each channel k , such that $g(q;k)$
1886 $\propto w^*(q;k);$
1887 a TCM codec;
1888 a pilot symbol CODEC element that integrates with said FFT-LS
1889 algorithm a link separation, a pilot and data signal elements
1890 sorting, a link detection, multilink combination, and equalizer
1891 weight calculation operations;
1892 means for diversity transmission and reception,
1893 and,
1894 means for input and output from and to a non-radio interface;
1895
1896 said set of nodes being linked according to design rules that favor the following
1897 criteria:
1898 subdividing said set of nodes ~~further comprising into~~ two or more proper
1899 subsets of nodes, with a first proper subset being ~~the~~ a transmit uplink /
1900 receive downlink subset, and a second proper subset being ~~the~~ a transmit
1901 downlink / receive uplink subset;
1902
1903 allowing each node in said set of nodes to simultaneously belong
1904 belonging to no more only as many transmitting uplink or receiving uplink
1905 subsets ~~than~~ as it has diversity capability means;
1906
1907 allowing each node in a ~~the~~ transmit uplink / receive downlink subset ~~has~~
1908 ~~no more~~ to simultaneously link to only as many nodes with which it will
1909 hold time and frequency coincident communications in its field of view,
1910 ~~than~~ as it has diversity capability means;
1911
1912 allowing each node in a ~~the~~ transmit downlink / receive uplink subset ~~has~~
1913 ~~no more~~ to simultaneously link to only as many nodes with which it will

1914 hold time and frequency coincident communications in its field of view,
1915 ~~than~~ as it has diversity capability means;
1916 allowing each member of a the transmit uplink / receive downlink subset
1917 ~~cannot hold to engage in simultaneous,~~ time and frequency coincident
1918 communications with any other member of that transmit uplink / receive
1919 downlink subset only if both that other member also belongs to a different
1920 proper subset and the communication is between different proper subsets;
1921 and,
1922 allowing each member of a the transmit downlink / receive uplink subset
1923 ~~cannot hold to engage in simultaneous,~~ time and frequency coincident
1924 communications with any other member of that transmit downlink /
1925 receive uplink subset only if both that other member also belongs to a
1926 different proper subset and the communication is between different proper
1927 subsets;

1928
1929 means for transmitting, in said wireless electromagnetic communications network,
1930 independent information from each node belonging to a first proper subset, to one
1931 or more receiving nodes belonging to a second proper subset that are viewable
1932 from the transmitting node;

1933
1934 means for processing independently, in said wireless electromagnetic
1935 communications network, at each receiving node belonging to said second proper
1936 subset, information transmitted from one or more nodes belonging to said first
1937 proper subset;

1938
1939 and,

1940
1941 means for deploying said set of nodes such that substantially reciprocal symmetry
1942 exists for the uplink and downlink channels by,
1943 if the received interference is spatially white in both link directions, setting

1944 $\mathbf{g}_2(q) \propto \mathbf{w}_2^*(q)$ and $\mathbf{g}_1(q) \propto \mathbf{w}_1^*(q)$ at both ends of the link,

1945 where $\{\mathbf{g}_2(q), \mathbf{w}_1(q)\}$ are the linear transmit and receive weights

1946 used in the downlink;

1947

1948 but if the received interference is not spatially white in both link

1949 directions, constraining $\{\mathbf{g}_1(q)\}$ and $\{\mathbf{g}_2(q)\}$ to satisfy:

1950

1951
$$\sum_{q=1}^{Q_{21}} \mathbf{g}_1^T(q) \mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n_1(q)) \mathbf{g}_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{\mathbf{R}_{\mathbf{i}_1 \mathbf{i}_1}(n)\} = M_1 R_1$$

1952

1953
$$\sum_{q=1}^{Q_{12}} \mathbf{g}_2^T(q) \mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n_2(q)) \mathbf{g}_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{\mathbf{R}_{\mathbf{i}_2 \mathbf{i}_2}(n)\} = M_2 R_2;$$

1954

1955 using any standard communications protocol, including TDD, FDD, simplex,

1956

1957 and,

1958

1959 means for optimizing the network by dynamically adapting the diversity

1960 capability means between nodes of said transmitting and receiving subsets.

1961

1962

1963 186. (NEW) An apparatus as in claim 185, wherein said a transmission/reception
1964 switch further comprises an element for tone and slot interleaving.

1965

1966 187. (NEW) An apparatus as in claim 185, wherein said TMC codec and SOVA bit
1967 recovery element are replaced with a Turbo codec.

1968